REMARKS

This Request for Reconsideration (hereafter "Request") is fully responsive to the final Office Action dated December 19, 2011, issued in connection with the above-identified application. Claims 2, 3 and 5 are pending in the present application. With this Request, no amendments have been made to the claims. Favorable reconsideration is respectfully requested.

I. Interview Summary

The Applicants thank Examiner Paik for granting the telephone interview (hereafter "interview") conducted on November 15, 2011 with the Applicants' representative. During the interview, the distinguishable features between the present invention (as recited in independent claim 2, as an exemplary independent claim) and the cited prior art were discussed in detail.

In particular, it was noted that Terada fails to disclose or suggest detecting a time change in light emission strength from a plasma or plume generated from a laser welded portion, and analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which has the same frequency variation of a laser output, as recited in independent claim 2.

It was further noted that Terada in col. 4, line 63-66 clearly discloses that a predetermined wave length is used for filtering the light emitted at the molten pool by performing welding testing, spectrum analysis and data processing. Thus, only a light emission from the molten pool is detected, not the light emission strength of a plasma or plume.

The Examiner indicated that he may be able to broadly interpret the reference such that the light emission from the molten pool would include or be equivalent to the light emission from the plasma or plume. However, the Examiner did indicate that further consideration of the reference would be necessary before making a final determination regarding the rejection to the claims. No specific agreement was reached during the interview.

II. Prior Art Rejection

In the Office Action, claims 2, 3 and 5 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Tsukamoto et al. (US 2004/0026381, hereafter "Tsukamoto") in view of Terada et al. (US 5,155,329, hereafter "Terada"), Chou et al. (US 5,961,859, hereafter "Chou"), and Kearney (US 4,446,354, hereafter "Kearney").

The Applicants respectfully traverse the rejection noted above. Specifically, the Applicants assert that the cited prior art fails to disclose or suggest at least all the features of independent claims 2 and 3.

Independent claim 2 recites *inter alia* the following features:

"…detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion;

analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which is a same variation frequency of the laser output; and

setting a laser output variation condition such as the waveform and the frequency so that the amplitude of the frequency component becomes a maximum." (Emphasis added).

Independent claim 3 recites *inter alia* the following features:

"...detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion;

setting an arbitrary threshold value to the time change in the light emission strength of the plasma or the plume; and

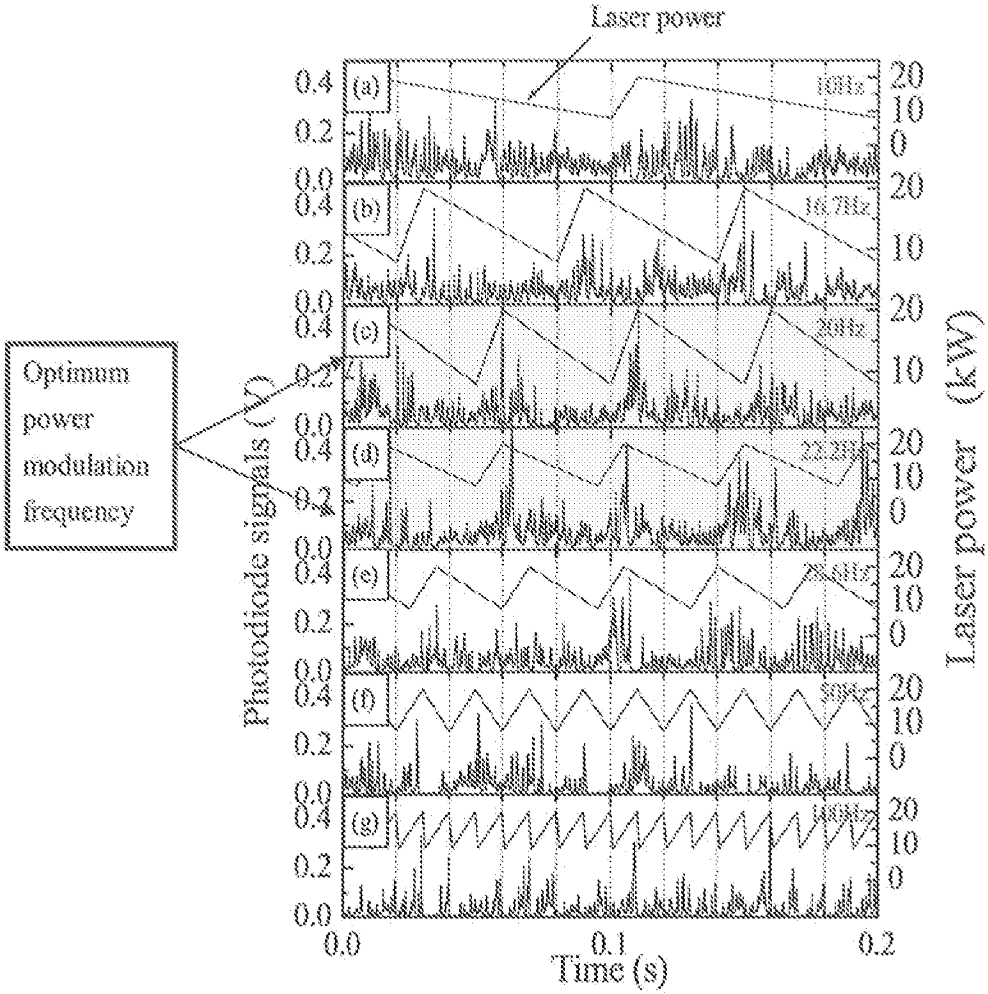
setting a laser output variation condition so that a sum of time at which the light emission strength becomes the threshold value or less is a minimum,

wherein laser output variation condition is set such that the sum of the time at which the light emission strength becomes the threshold value or less is set to a range between 2ms to 12ms. (Emphasis added).

To prevent weld defects, it is important to optimize conditions of variations in the laser output. The present invention (as recited in independent claims 2 and 3) has determined that the peak of the amplitude in the frequency component of the light emission of a plasma or plume which matches with the variations in the frequency of the laser output is the largest at optimum welding conditions (see Applicants' disclosure pg. 9, lines 3-8 and Fig. 4).

Fig. A is a diagram illustrating a time change of the laser power and the plasma emission strength measured for various frequencies of the laser power modulation. The optimum condition of the laser power modulation for suppressing weld defects is determined by detecting the relationship with the time change of the plume or plasma emission strength (i.e., the intensity of the ultraviolet radiation from the plume or plasma and the time change of the laser output).

Fig. A



As noted above, Fig A (i.e., (c) and (d)) shows the time change of the plasma emission strength when welding is conducted under the optimum laser power modulation frequencies (e.g., 20 and 22.2 Hz). Under these optimum conditions, the laser emission strength corresponds well to the modulated laser power and weld defects can be avoided. On the other hand, when the laser output modulation frequencies move away from the optimum frequencies, the laser emission strength does not correspond to the laser output modulation (e.g., Fig. A (f) and (g)).

The present invention (as recited in independent claims 2 and 3) detects and analyzes the time change in light emission strength of a plasma or plume generated from a laser welded portion, and determines and sets the optimum laser output modulation condition. Accordingly, the light emission of the plume or plasma (i.e., the ultraviolet radiation from the plume or plasma) is detected.

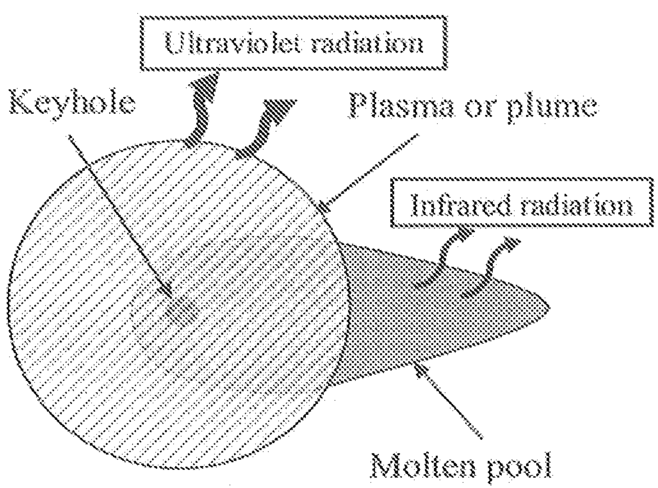
In the Office Action, although the Examiner relies on the combination of Tsukamoto, Terada, Chou and Kearney for disclosing or suggesting all the features recited in independent claims 2 and 3, the Examiner relies primarily on Terada, Chou and Kearney for disclosing or suggesting the detection of the time change in light emission strength of a plasma or plume generated from a laser welded portion, and the determination of the optimum laser output modulation condition.

Specifically, the Examiner relies on Fig. 4 and 6 and col. 4, lines 33-43 of Terada; col. 3, lines 8-18 of Chou; and Kearney generally.

Terada, with reference to Figs. 4 and 6, discloses a relationship between a waveform of the pulsating laser beam and a waveform of the emission intensity at a weld zone. As described in Terada, the waveform related to emission intensity stays at a certain level while the welding beam input is present, and decreases abruptly a short time after the welding beam input drops (see also col. 4, lines 33-43).

Fig. B illustrates the light emission observed during laser welding.

Fig. B



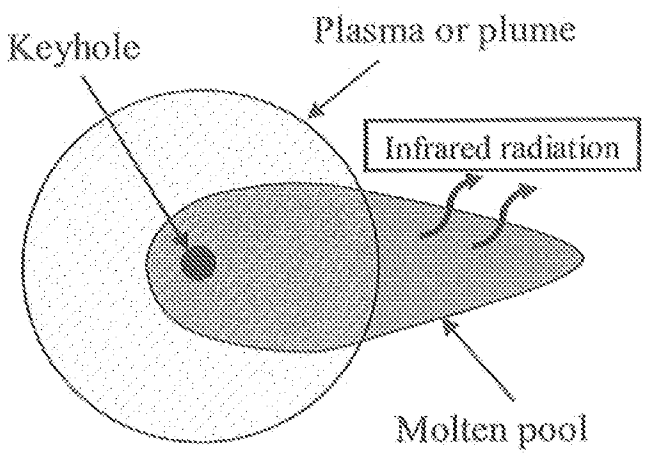
A plume or plasma is formed by metal vapors generated from a key hole formed at the laser irradiation position. High intensity ultraviolet radiation is emitted from the plume or plasma. Additionally, an elongated molten pool is formed around the laser irradiation position. Relatively low intensity infrared radiation is emitted from the molten pool melted by the laser.

A temperature change of the molten pool can be determined by detecting the light emitted from the molten pool because the intensity of the infrared radiation from the molten pool generally correlates with the temperature of the molten pool. In Terada (with reference to Figs. 4 and 6), the intensity of the infrared radiation emitted from the molten pool during laser welding is detected based the relationship between the intensity of the infrared radiation and the temperature.

Terada in col. 4, lines 63-66 also discloses that a predetermined wavelength used in filtering the light emitted at the molten pool can be determined by performing weld testing, spectrum analysis and data processing. Strong ultraviolet radiation emitted from the plume or plasma can be a large source of noise with regard to the detection of the infrared radiation emitted from the molten pool. Therefore, Terada (e.g., in col. 4, lines 63-66) discloses using an interference filter that can transmit only the infrared radiation of the molten pool.

Fig. C discloses an image after being transmitted through the interference filter of Terada.

Fig. C

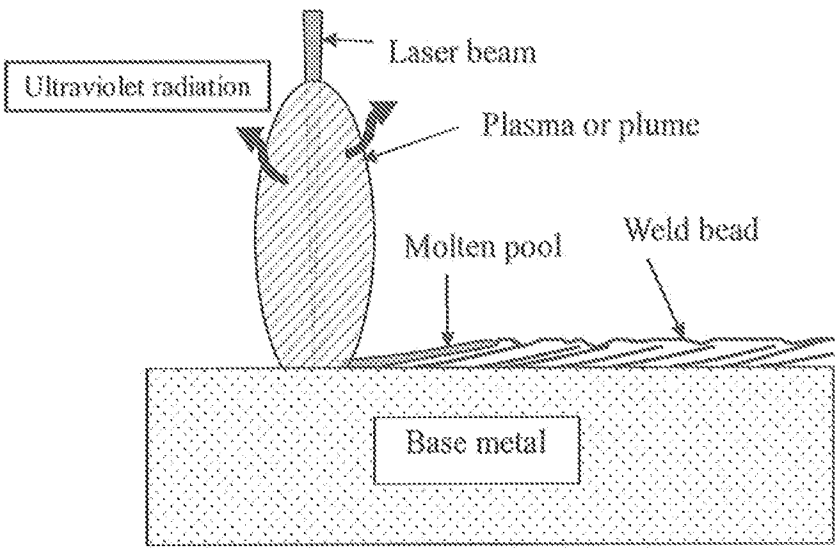


As noted above in Fig. C, high ultraviolet radiation (i.e., radiation from the plume or plasma) is effectively removed by the interference filter and only the infrared radiation from the molten pool can be detected. In fact, Terada in col. 4, line 2 discloses wavelengths of "0.8 μm or 0.94 μm" as examples for filtering wavelengths, which are consistent with the wavelength region of infrared radiation. Thus, Terada (e.g., col. 4, lines 63-66) clearly discloses that the intensity of the infrared radiation emitted from the molten pool during laser welding is detected, which is further supported by Fig. 1 of Terada (i.e., disclosing the use of a sensor disposed over a welded portion to detect a light emitted from a molten pool).

Thus, Terada discloses a monitoring method of the welding beam input and depth of penetration based on the linear relationship between the intensity of the light emitted from the molten pool and the welding beam input or depth of penetration. Thus, the intensity of the infrared radiation from the molten pool is clearly detected in Terada, which is completely different from the present invention (as recited in independent claims 2 and 3).

With the present invention (as recited in independent claims 2 and 3), the intensity of the infrared radiation is not detected, but, instead, the ultraviolet radiation is detected. That is, a sensor is disposed in the horizontal direction to the base metal to be welded. Fig. D is an exemplary view of welding behavior during laser welding in the present invention (as recited in independent claims 2 and 3).

Fig. D



As illustrated above, a plume or plasma is produced by the interaction between the laser beam and the molten metal by irradiation of the laser. Since the interaction frequently takes place around the keyhole, the base metal is violently vaporized. The intensity and behavior of the ultraviolet radiation from the plume or plasma is significantly different from that of the infrared radiation from the molten pool because the molten pool temperature does not vary as quickly.

The present invention (as recited in independent claims 2 and 3), is directed to a method for detecting and analyzing frequencies regarding the time change of plasma or plume emission strength, and determining and setting the optimum laser output modulation condition. An

important aspect of the present invention (as recited in independent claims 2 and 3) is the detection of the light emission of the plume or plasma (i.e., the ultraviolet radiation from the plume or plasma), which is completely different from the detection of the intensity of the infrared radiation from the molten pool, as disclosed in Terada.

Moreover, the Applicants assert that Chou and Kearney fail to overcome the deficiencies noted above n Terada.

Chou in col. 3, lines 8-18 discloses a method of monitoring laser weld quality. The method includes monitoring, at a position above a surface and as a function of time during the laser welding process, the spatial distribution of the intensity of light emitted from a plasma. Additionally, a numerical value is assigned to at least one physical dimension of the plasma to monitor the intensity of light, and the numerical value is compared to a predetermined value, wherein the predetermined value is representative of acceptable weld quality.

In Chou (i.e., in col. 3, lines 8-18), a light emitted from the weld plasma above the surface of a workpiece irradiated by a laser beam is monitored. However, Chou fails to disclose or suggest detecting the time change in light emission strength of a plasma or plume generated from a laser welded portion, and determining and setting the optimum laser output modulation condition based on such detection.

Conversely, with the present invention (as recited in independent claim 2), an optimum condition of an output modulation is determined and set by detecting a time change in light emission strength of a plasma or plume generated from a laser welded portion.

In the Office Action, the Examiner alleges that Kearney discloses that it is well known that the amplitude and wavelength of radiation emitted by a welding arc or plasma is detected by a sensor to determine weld conditions. However, the Applicants assert that Kearney still fails to disclose or suggest a method of detecting and analyzing frequencies regarding the time change of plasma or plume emission strength, and determining and setting the optimum laser output modulation condition, as recited in independent claims 2 and 3.

Based on the above discussion, no combination of Tsukamoto, Terada, Chou and Kearney would result in, or otherwise render obvious, the features of independent claims 2 and 3. Likewise, no combination of Tsukamoto, Terada, Chou and Kearney would result in, or otherwise render obvious, the features of claim 5 by virtue of its dependency from independent claim 2.

III. Conclusion

In light of the above, the Applicants submit that all the pending claims are patentable over the prior art of record. The Applicants respectfully request that the Examiner withdraw the rejections presented in the outstanding Office Action, and pass the present application to issue. The Examiner is invited to contact the undersigned attorney by telephone to resolve any issues remaining in the application.

Respectfully submitted,

Susumu TSUKAMOTO et al.

/Mark D. Pratt/
By 2012.03.19 12:54:30 -04'00'

Mark D. Pratt
Registration No. 45,794
Attorney for Applicants

MDP/lkd
Washington, D.C. 20005-1503
Telephone (202) 721-8200
Facsimile (202) 721-8250
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